
How can petrophysics, fluid inclusions and clay minerals help the characterization of a paleo-geothermal system? The example of Terre-de-Haut (Les Saintes archipelago, Guadeloupe)

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Résumé

Bouillante geothermal system (Basse Terre, Guadeloupe) is harnessed for electricity production. Deep drillholes provide a vertical view of the geothermal reservoir. Terre-de-Haut is considered as its surface analog which, being exhumed, provides a nearly horizontal section into the paleo-reservoir. As at Bouillante, the geothermal reservoir developed at the intersection between faults. Some zones of Terre-de-Haut are highly hydrothermalised with the thorough transformation of primary minerals into clay (horizontal succession of smectite, illite, chlorite). In this zoning, the highest temperature (indicated by the presence of chlorite) is found at the core of the reservoir and the lowest temperatures (illite and then smectite) at its surroundings. In addition, field and microscopic observation together with petrophysical measurements (porosity) show that even fresh rock samples are porous and permeable, allowing fluid flow and then hydrothermal alteration. The combination of 1D vertical data at Bouillante and 2D horizontal distribution of clay minerals and fractures on Terre-de-Haut allows for a 3D schematic representation of the geothermal systems of the Guadeloupe archipelago and suggests that they are of hectometer-size (hm-size). Fluid inclusions in newly-formed quartz together with geothermometry on chlorite crystals suggest three episodes during functioning and cooling of this system: (i) a temperature of at least 240–270 °C from fluid inclusions trapped in the core of a euhedral quartz, (ii) chlorite formation at about 120 °C, and (iii) temperatures of ~50 °C - or less - in fluid inclusions of outer growth zones in the same euhedral quartz. The hydrothermal fluid was of low salinity (2 wt% NaCl, probably of meteoric and sea water origin). Additionally, a second type of fluid inclusions observed in a banded quartz vein indicates at least an episode of a CO₂-(H₂O) fluid, with traces of H₂S. Hence, some similarities can be highlighted between Terre-de-Haut and the Bouillante active geothermal system in terms of the highest temperatures of circulation events and gas composition, despite a difference in fluid origin. In addition, the N70 trending fractures, that have been identified as drains for the hot temperature fluids have to be considered for future geothermal exploration.

Mots-Clés: geothermal system, Guadeloupe, Bouillante, Terre, de, Haut, fluides inclusions, clay minerals, petrophysics, cooling of the paleo, geothermal system

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